Lexington Public Schools

1557 Massachusetts Avenue ❖ Lexington, Massachusetts 02420

Carol A. Pilarski
Assistant to the Superintendent

(781) 861-2553
email: cpilarski@sch.ci.lexington.ma.us
fax: (781) 863-5829

To: Dr. Paul Ash
Members of the Lexington School Committee

From: Carol A. Pilarski
The Mathematics Curriculum Review Committee

Re: **Executive Summary:**
Update on Year One of the Mathematics Curriculum Review

Date: June 12, 2007

I am delighted to report that the Mathematics Curriculum Review Committee has accomplished a tremendous amount of work during this first year of the mathematics review process. Allow me to begin by acknowledging the hard work and many efforts of our committee members. Attached to this document (Appendix #1), you will find a list of individuals who have given expertly and unselfishly of their time and energy to this important task. This group has spent many days and hours working together collecting data, exploring the research, probing issues, conversing, and discussing varying and challenging points of view. The entire committee assembled on August 28th and 29th, 2006; October 4th, 2006; January 17th, 2007; and May 9th, 2007. Additionally, the various sub-committees met multiple times throughout the course of the year to pursue their individual assignments. I believe I speak on behalf of the entire group when I say that it has been an exhilarating experience for all of us. We have learned much from our collective work and from each other. We are enthusiastic about continuing our efforts in Year 2 of the process.

In the information provided herein and in a presentation that I will be making before you on Tuesday, June 12th, I have summarized and highlighted the accomplishments and findings of the Mathematics Curriculum Review Committee for **Year One**.

The **Goals for Year 1**, as outlined in a document previously shared with the School Committee regarding **all** programmatic reviews, included the following:

- Assemble K-12 content-specific curriculum task forces and study groups.
- Study content-related literature.
- Review updated Massachusetts Curriculum Frameworks and current local curriculum to determine alignment.
- Review current resources and materials to determine alignment of curriculum and resources currently being used.
- Review accomplishments or areas of progress in supporting district goals.

- Analyze MCAS and other student performance data to assess strengths and weaknesses of the current curriculum.
- Summarize data analysis.
- Make recommendations for updated curriculum.
- Develop standards-based benchmark outcomes/assessments consistent with revised curriculum.
- Study research-based recommended practices.

It should be noted that we have accomplished 90% of our Year 1 goals. We will begin the work related to the last two “bullets” listed above: “standards-based benchmarks and assessments” in June at the K-5 level, and proceed with the “study of research-based recommended practices” in Year 2.

For purposes of this report, I have divided the information into five (5) categories for ease of reading and clarity.

I. The Process

At the beginning of the review process, the larger committee was divided into 3 sub-groups to focus attention on particular areas of study: 1. Review of Research and Literature 2. Analysis of Student Performance 3. Review of Local Alignment with the Massachusetts State Frameworks.

II. Research and Literature

The review of the Research and Literature was extensive. The committee has summarized their findings in the following narrative:

The literature clearly indicates that the learning of mathematics has changed significantly for today’s students compared to those of a generation ago. Newly developed national standards and state frameworks have prescribed substantive changes in mathematical content coverage, the types of mathematical proficiencies that are taught and valued, and the balance between skill development and conceptual understanding. The National Science Foundation funded the development of several new textbook series that compete with more traditional textbooks from established publishers. Some aspects of these reforms have led to heated debates, especially about the relative importance of computational skills versus conceptual understanding.

The development of mathematics teaching and learning over the past two decades, both nationally and locally, has been strongly influenced by a series of national standards and state curriculum frameworks. The first of these was the National Council of Teachers of Mathematics (NCTM) *Curriculum and Evaluation Standards for School Mathematics* (1989) which prescribed significant changes in the content and methodology of mathematics instruction, encouraging the development of students’ mathematical process skills and “mathematical power” alongside more traditional skill and content goals. “According to this new perspective, the global transformation from an industry-based society to an information-based one involves a corresponding transformation of expectations for mathematical literacy. The mathematical competence necessary for success in the information age includes the familiar fluency with facts and skills, but also requires sophisticated mathematical reasoning and problem solving in a variety of contexts.” (*Choosing a Standards Based Mathematics Curriculum*, 2000) The NCTM’s current standards document, *Principles and Standards for School Mathematics* (2000) outlines 6 principles that characterize high-quality mathematics instruction; 5 content standards spanning the K-12 levels; and 5 standards describing mathematical processes to be learned by students.

The NCTM *Principles and Standards* lists the following 6 principles as the basis for quality mathematics education:

Equity: High expectations, academic excellence and strong curricular and instructional support for all students.

Curriculum: Coherent and well-articulated curriculum across the grades with an emphasis on big mathematical ideas that are interconnected to other disciplines and to real-life experiences.

Teaching: Understanding what students know and need to learn, and then challenging and supporting them to learn it well with a repertoire of effective pedagogical strategies.

Learning: The importance of students learning with understanding is emphasized, with the aim of better preparing students for the mathematical problems they will face in their future lives.

Assessment: Supports learning and furnishes information to teachers and Students on an on-going basis providing valuable data for advancing achievement.

Technology: An essential piece influencing teaching and learning both as a tool for expanding the classroom experience and enriching procedural and conceptual understanding.

The NCTM's standards are subdivided into **5 standards describing content** (areas of mathematics in which students should develop proficiency) and 5 standards describing processes (aspects of mathematical capability for students to develop). The content standards are *Number and Operations*, *Algebra*, *Geometry*, *Measurement*, and *Data Analysis and Probability*. Each of these content standards spans the K-12 range; for example, Algebra is not solely a secondary topic, foundational algebraic ideas are included as early as grades K-2. This chart demonstrates a more integrated approach to topics with several areas appearing at each grade level. These topics are to be developed in "connection" with each other rather than in "isolation," re-appearing at various grade levels in increasingly sophisticated forms.

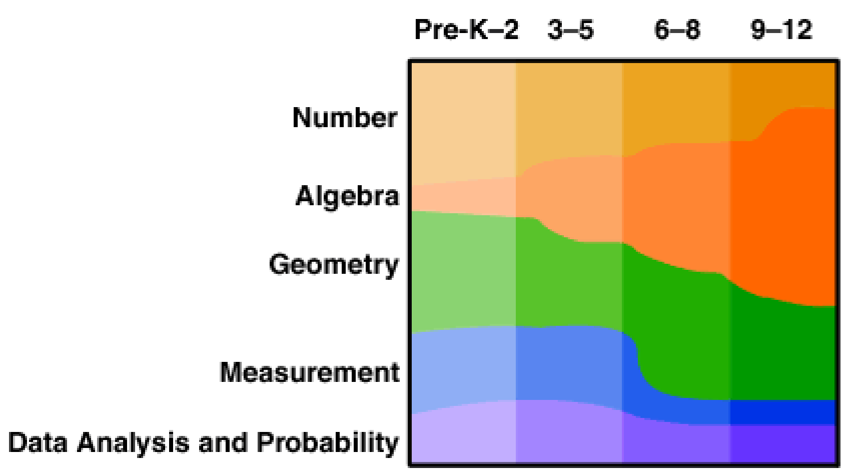

Fig. **3.1.** The Content Standards should receive different emphases across the grade bands.

Similarly, the **<u>5 process standards</u>** *Problem Solving*, *Reasoning and Proof*, *Communications*, *Connections*, and *Representation* are described as a progression across all the grades. Of particular note are the *Communications* standard which encourage the development of students' abilities to read, write, listen, and speak about mathematics, and the *Connections* standard, which emphasizes connections both between mathematical topics and to areas where mathematics is applied.

Combined, the CONTENT and PROCESS standards evoke the essential elements of a highly effective program that includes: mastery of skills and concepts, mathematical communication and thinking, positive attitudes towards mathematics, and critical views of teaching and learning.

In Massachusetts, The ***<u>Curriculum Frameworks</u>*** in mathematics were first published in the mid-1990s and revised subsequently. The *Frameworks* mostly reflect the educational philosophy of the NCTM documents, but are more prescriptive of specific topics to be covered in certain grade ranges. Specific topics covered at certain grade levels can and do vary considerably from state to state. Most recently, in 2006 the NCTM published *Curriculum Focal Points* identifying three key topic areas to be covered in each of the grades K-8 in order to more clearly articulate specific expectations for each grade level on a national level; however, neither the NCTM documents nor the Massachusetts *Frameworks* fully describe a mathematics curriculum for schools to follow. This has been left to local discretion.

The vision of mathematics teaching and learning promoted by the NCTM has influenced significant widespread changes in mathematics education. However, some parts of the NCTM vision have proven controversial. In particular, some critics feel that the traditional development of calculation skills has been compromised, to the detriment of students. The NCTM's latest *Curriculum Focal Points for Pre-Kindergarten through Grade 8 Mathematics: A Quest for Coherence* (2006) was written by a committee of nine educators and specifies the three most significant math concepts students should learn in each grade level. These focal points are not specific enough to guide daily instruction but are designed to serve as overarching "big ideas" for specific grade levels. The document has generated renewed controversy, with some reform critics and media outlets characterizing it as a "back-to-basics" retreat (*Wall Street Journal*, Sept. 12, 2006). NCTM, itself, however, maintains that it has always supported basic skill development but that such skills should be developed with understanding (NCTM President Francis (Skip) Fennell, letter to *Wall Street Journal*, Sept. 26, 2006).

Paralleling this controversy, there now exist mathematics textbooks reflecting a wide range of pedagogical approaches. The mathematics textbook market is currently divided between texts from mainstream commercial publishers, and several series of "reform" textbooks that were developed in the 1990's as model curricula supported by grants from the National Science Foundation. Both types of textbooks have evolved over the years, but the reform textbooks tend to implement the NCTM vision more deeply and wholeheartedly. Commercial publishers are deterred from making significant content changes due to marketing realities and the varied textbook adoption practices of different states. (Robert E. Reys, *Curricular Controversy in the Math Wars*, Phi Delta Kappan, Nov. 2001).

There exists a variety of opinions on which textbooks are more effective, but relatively few rigorous studies of this question. The effectiveness of a textbook series is difficult to establish scientifically and requires synthesis of multiple modes of evaluation. (*On Evaluating Curricular Effectiveness: Judging the Quality of K-12 Mathematics Evaluations,* National Research Council, 2004) Regarding traditional textbooks, the lead researcher of the Third International Math and Science Study summarizes, "The evidence indicates that the traditional curriculum and instructional methods in the United States are not serving our students well." (James Hiebert, *Journal for Research in Mathematics Education*, Jan. 1999.) Studies by the U.S. Department of Education (1999) and the American Association for the Advancement of Science (2004) have judged several of the NSF-funded curricula to be effective based on measurable differences in student learning (National Math Panel Testimony, Nov. 6, 2006). And recently, the federal *What Works Clearinghouse* began releasing ratings of the effectiveness of elementary math textbook series. Reviewing four textbook series that form about 50% of the elementary textbook market, the study found that only one of them, the reform textbook series *Everyday Mathematics* (used in Lexington K-5), had research-based evidence of positive effects on student learning (Education Week, Jan. 24, 2007). The Lexington Public Schools currently relies on different types of textbooks at different grade levels. For over a decade, grades K-5 have used one of the early reform textbook series, *Everyday Mathematics*. Grades 6-12 use textbooks from a variety of mainstream commercial publishers, sometimes significantly supplemented by teacher-generated materials that actively engage students in mathematical thinking. A growing body of research on developing and expanding mathematical proficiency examines the types of mathematics instruction that best support the development of students' mathematical skills.

One report (*Adding It Up: Helping Children Learn Mathematics*, National Research Council, 2001) describes these five aspects of mathematical proficiency:

- *Conceptual understanding* of math concepts, operations, and relations.
- *Procedural fluency* in carrying out math skills accurately, efficiently, and appropriately.
- *Strategic competence:* ability to formulate, represent, and solve problems.
- *Adaptive reasoning:* logical thought, reflection, explanation, and justification.
- *Productive disposition:* inclination to see math as useful and worthwhile and a confidence in one's own mathematical effectiveness.

The report emphasizes that these five strands are "interwoven and interdependent" and need to be emphasized across all grades and curricular strands. It asserts that the mathematics students need to learn today is different from that of prior generations, and that all students need to reach these kinds of mathematical proficiency.

The research clearly indicates that most educators agree that mathematics education in the United States really won't change until training and preparation of teachers improve. "There is increasing attention to the need for elementary and middle grades teachers to have strong content knowledge for teaching which includes understanding the relevant and related mathematics, effective instructional practices, and how students learn," says Weimar in a special report responding to the NCTM's Curriculum Focal Points.

Liping Ma's cross-cultural study *Knowing and Teaching Mathematics: Teachers' Understanding of Fundamental Mathematics in China and the United States* (1999)further emphasizes this need and finds that in the United States, often those teaching mathematics at the elementary level are lacking a "profound understanding of fundamental mathematics" that is necessary for teaching with understanding. Such teachers often lack training in understanding the big ideas of mathematics and the multiple representations of mathematical ideas. This deficit suggests a need for professional development to support new modes of math teaching and learning.

III. <u>The Mathematics Curriculum: A Statement of Purpose</u>

In reviewing the Research and Literature and reflecting upon the goals and objectives of an exemplary Mathematics Program for the Lexington Public Schools, the committee created the following Statement of Purpose to describe its mission and vision. This statement serves as an affirmation of our goals and the foundation for our review. It characterizes all of those elements necessary for a quality mathematics program that will serve the needs of **<u>all</u>** students.

> *The goal of the Lexington Public Schools mathematics program is to offer to all students a rich and engaging mathematics curriculum that focuses on important and essential mathematics, learned with understanding and depth. The program's aim is to enable every student to achieve full potential as a mathematics learner, based on a conviction that everyone can succeed when challenged by high expectations and offered strong support. The program takes a balanced approach to developing proficient skills, conceptual understanding, and mathematical habits of mind. Students are given opportunities to explore and discover mathematical ideas, to build their mathematical knowledge, and to cultivate their thinking, creativity, reasoning, and problem solving*

capabilities. Teachers seek to create learning experiences that are developmentally appropriate; to address varied learning styles, and use a variety of mathematical approaches and representations. Students are encouraged to communicate their mathematical ideas, to become confident and perseverant in using mathematics, and to appreciate the power, relevance, and beauty of mathematics.

IV. Areas of Strength

In your packet, you will note that I have included samples of the templates locally designed to collect information from **all** mathematics teachers in the district K-12. (Appendix #2) These templates included the specific grade level "learning standards" as outlined by the Massachusetts Curriculum Frameworks for mathematics, in addition to several questions about pedagogical practices, professional development, and available resources. A separate survey was also formulated at the K-5 level to gather data about other instructional information the committee believed to be valuable in acquiring a more thorough understanding of the overall "state" of the mathematics program in our district. (Appendix #3)

A. K-5 level: The Lexington Public Schools adopted the Everyday Mathematics program (EDM) as the primary instructional vehicle more than 15 years ago. Expectations for student learning at each grade level are defined at the district level in the internally developed Elementary Mathematics Curriculum document (1997). Benchmarks for student learning at the state level are defined in the Massachusetts Mathematics Curriculum Frameworks (2002, 2004).

For the most part the findings at the **K-5 level** indicated that:

- Overall, the elementary mathematics program is aligned with the frameworks. It should be noted that at the primary level (K-2), Lexington teachers and specialists question the developmental appropriateness of some of the state benchmarks at the early grades. However, by grade 3, most of these differences are resolved and performance on the MCAS test in these areas are consistently well above state averages.
- Expectations of the district and the Everyday Mathematics program are consistently more ambitious than those outlined by the state.
- MCAS results indicate overall strong performance by students in all grades tested.
- At the culmination of the elementary program, MCAS results indicated that our 5th grade students placed overall 1st in the state in mathematics (1/303).

B. 6-8 level: The Middle Schools' Mathematics program demonstrates curriculum coordination with the Massachusetts State Frameworks for a great majority of strands and standards. The staff collaborates regularly: researching, planning, reviewing and implementing concepts and materials to strengthen the mathematical knowledge of all learners. MCAS data indicates strength in the performance levels of Advanced and Proficient, with all grades scoring 76% of students these categories. These results are consistently higher than state results.

- **Grade 6** is fully aligned with the frameworks, particularly in the following areas: Number Sense & Operations, Data Analysis, Statistics & Probability, Measurement, and Geometry. However, we are not completely aligned in the area of Patterns, Relations, & Algebra, specifically standard [6.P.5]: "solve linear equations using concrete models, tables, graphs, and paper/pencil methods" and standard [6.P.7]: "identify and describe relationships between two variables with a constant rate of change; contrast these with relationships where the rate of change is not constant." Although this material is covered more thoroughly in higher grades, it needs to be taught to grade 6 students. Further investigation is needed with the frameworks document and the materials we use to insure alignment.

- **Grade 7** is fully aligned with the frameworks in the Number Sense & Operations and Data Analysis, Statistics, and Probability strands. With regard to Patterns, Relations, & Algebra, specifically standard [7.P.3]: "create and use symbolic expressions for linear relationships and relate them to verbal, tabular, and graphical representations" and [7.P.5] "identify, describe, and analyze linear relationships between two variables; compare positive rate of change, e.g., y=3x+1, to negative rate of change, e.g., y=-3x+1", We recommend that these items are taught more consistently throughout grade 7. Linear equations will be addressed and become a skill uniformly taught in this grade. Similarly, we have concerns with regard to the Geometry strand specifically standard [7.G.5]: "use a ruler, protractor, and compass to draw polygons and circles". In addition to increased emphasis on this particular standard, we have found it is important to place more emphasis on geometry in general. This is supported by the MCAS scores we studied/analyzed in our Action Research. This is a direct result of the design of the eighth grade program which devotes a full or half year of algebra to the majority of its students. In the Measurement strand, our studies indicate that standard [7.M.2]: "given formulas, convert from one system of measurement to another, use technology as appropriate" is an area of concern. There is some disagreement with this standard as scientists and mathematicians have traditionally de-emphasized the need for and validity of converting between systems of measurement. The two systems function independently of one another and experts discourage the practice of converting between the two systems. Consequently, we have not emphasized this standard. We recommend more widespread use of the MCAS reference sheet (which contains formulas and conversions) and to apply concrete models for the success of the standard [7.M.3]: "demonstrate an understanding of the concepts and apply formulas and procedures for determining measures, including those of area and perimeter/circumference of parallelograms, trapezoids, and circles; given the formulas, determine the surface area and volume of rectangular prisms and cylinders; use technology as appropriate."

- **Grade 8** is fully aligned in the areas of Number Sense & Operations, and Patterns, Relations & Algebra. In Geometry, we have alignment due to the coverage in grades six and seven, but recommend that there be more emphasis in grade 8. Specifically standard [8.G.4]: "demonstrate an understanding of the Pythagorean Theorem; apply the theorem to the solution of problems."
  In the Measurement strand, we are not fully aligned with standard [8.M.2]: "given the formulas, convert from one system of measurement to another; use technology as appropriate." This is the same discrepancy as in grade seven in which we stated that science and math experts discourage converting between the two systems (metric and English standards). With regard to the Data Analysis, Statistics & Probability strand [8.D.1]: "describe the characteristics and limitations of a data sample; identify different ways of selecting a sample, e.g., convenience sampling, responses to a survey, random sampling", our findings indicate that there is a need for more emphasis here with a strong focus on vocabulary.

- Additional information regarding awards/achievements, which were not an official part of the curriculum review, but do serve as indicators of success are included in Appendix #4.

C. 9-12 level: The Checklist for Grade Span Learning Standards was developed as a compilation of the results of four course-specific surveys of Lexington High School mathematics teachers to determine the content coverage and alignment of our core curriculum with the Massachusetts State Frameworks. The teacher responses to the surveys were informed by on-going discussions last year leading up to the development of common departmental final exams in June of 2006. Based on the results of these inventories, the following statements can be made:

- Core curriculum is aligned with Massachusetts Frameworks for all but one learning standard within the grade 9-10 grade span: [10.G.11] Use vertex-edge graphs to model and solve problems.
- The 9-10 grade span learning standards constitute the essential curriculum for preparation for the MCAS mathematics examination which is administered in May of the sophomore year for all students. In the spring 2006 examination, 77% of LHS students achieved at the *Advanced* performance level and 11% achieved at the Proficient level. A significant percentage of our students are able to demonstrate deep understanding of mathematical concepts on this high stakes test.
- Core curriculum is aligned with the Massachusetts State Frameworks for all but two learning standards: [12.G.3] Use the notion of vectors to solve problems. Describe addition of vectors and multiplication of a vector by a scalar, both symbolically and geometrically. Use vector methods to obtain geometric results [12.D.1] Design surveys and apply random sampling techniques to avoid bias in the data collection.
- Many core topics are spiraled throughout the four-year curriculum enabling students to develop mastery by the end of high school.
- The substantive four-year college-preparatory sequence enables students to continue their academic studies in mathematics, science, or a mathematics-related field as well as being mathematically literate for whatever discipline they pursue as an educated and informed citizen.
- The department strives for consistent coverage of the core topics across all sections of the same courses. Although we have common final exams that only require at least 80% common questions, we have approximately 95% commonality across all sections of the same course. The mathematics department publicly disseminates its own final exams on the department website on a fixed schedule so that students have a clear sense of what they should know and be able to do by the end of each course.
- Some courses have implemented mid-year (cumulative) assessments and we are looking at the possibility of departmental implementation of this promising practice that contributes to retention of procedural skills and deeper conceptual understanding.
- Additional information regarding awards/achievements, which were not an official part of the curriculum review, but do serve as indicators of success are included in Appendix #4.

V: <u>Areas in Need of Improvement/Recommendations:</u>

While there are specific needs that have been acknowledged at each of the 3 grade level cohorts, those areas recognized as being in "Need of Improvement" generally fall into the following categories and are mentioned consistently and emphatically in each grade level report as requiring attention and further study.

- Where 'concerning' mis-alignments have been identified in the correlation of local curriculum to the State Frameworks, adjustments will be made to rectify these throughout the curriculum re-writing process K-12.
- Increased Professional Development and Teacher Training focused on differentiating instruction and addressing various learning styles designed to meet the wide range of learners: support for struggling students having difficulties with executive functioning skills, completion of homework assignment, organizational and attention issues; support for students receiving a warning or needs improvement on MCAS and those not making adequate yearly progress as identified by the state; challenge for high performing students; additional language and content support for ELL students; accommodations for the increasing number of students on the autism spectrum; specific accommodations for students on 504 plans; strategies to address the achievement gap; methods to enhance and advance the performance levels of the African-American population. Special attention needs to be paid to these cohorts in any future efforts around professional development and teacher training.

- Clarke Middle School has not met AYP (Adequate Yearly Progress) in mathematics for the SPED sub group.
- Clearer definition of time to be allotted to direct instruction of mathematics at the elementary level.
- Training in the use of formative assessments to inform instruction.
- Increased training in the use of technology as an instructional tool.
- Provision of additional materials to support the above mentioned varied instructional strategies.
- Increased grade level and cross-grade sharing opportunities within and among schools to promote collaboration that will bridge the overall understanding of a comprehensive and well-articulated K-12 program.
- Focused attention and regular meetings for teachers at key transitional levels to further understanding of curriculum and student needs: grade 5 to 6 and grade 8 to 9.
- Increased Regular Education and Special Education collaboration and professional development/training in the area of mathematics
- Expanded opportunities for teachers at the K-5 level to deepen their understanding and competency in mathematics content.
- Formal presentation of a clearly articulated, comprehensive, and coherent K-12 curriculum document.
- Common grade level assessments (grades 5-8) to better inform individual student instruction and evaluate curriculum effectiveness.
- Increased integration of mathematical topics as secondary students often experience a “disconnect” across the various branches of mathematics due to an “artificial” separation by subject-specific courses (i.e. Algebra I, Geometry, Algebra 2, etc.) There is a need to strike a better balance and distribution across courses to establish the “connective tissue” of mathematics.
- Increased balance in teaching for mastery between spiraling topics over multiple courses and choosing topics that are taught deeply and in context so that students understand and retain the concepts without the need to re-visit them in another course.
- The curriculum should better enable all students to connect and apply mathematics to areas of interest in other disciplines, across other branches of mathematics, and in real-life applications.

VI. Next Steps:

- Creation of a clearly articulated, comprehensive, and coherent K-12 curriculum document. The K-5 curriculum writing is scheduled to begin in June, 2007. We will build at grade levels 6 through 8 and then 9 through 12 upon completion of the K-5 document. The 6-12 work will begin in Year 2.
- Hiring of 2 mathematics intervention specialists (1.0 FTE to be assigned to each middle school) to support the learning of at-risk students. This is viewed as a preventive measure that can assist in decreasing the number of students referred to Special Education.
- Steps to address the need recognized in the category of professional development and teacher training in curriculum-specific areas are currently being discussed by the Professional Development Committee.
- The meeting schedule for departments is also being addressed by the Professional Development Committee in an effort to balance the need for cross-grade and cross- school sharing and collaboration. “Time” is recognized as a valuable and limited resource with multiple demands from varied sources: district-wide, school based, and programmatic matters.
- Review of various textbook publications and material resources for possible implementation: Year 2

- Formation of committees and study groups to explore the needs of special student populations i.e. ELL, 504, Special Education, etc.: Year 2.
- Recommendation about time allotment at the K-5 grade level for mathematics instruction: Year 2
- All other items bulleted in the "Areas in Need of Improvement" segment of this report will be addressed in the next two years of the committee's work.

In conclusion, I hope that you will find this report helpful in understanding the status of the work accomplished by the committee in its first year. I look forward, along with other members of the review committee, to answering any questions you might have when we meet on June 12th.